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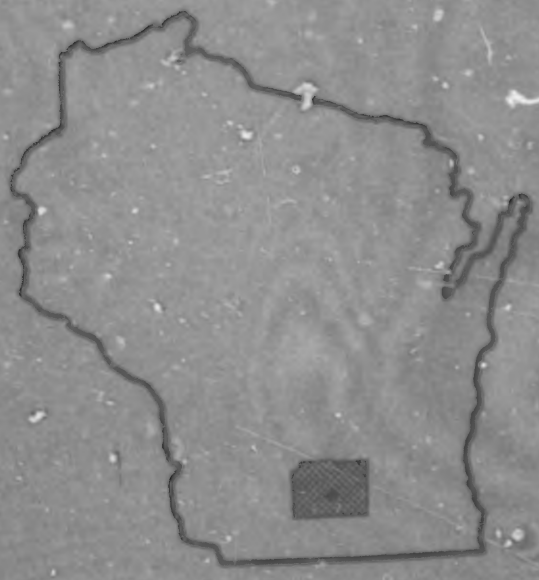
COMPLETED

FLOOD INSURANCE STUDY

ORIGINAL

CITY OF MADISON, WISCONSIN

DANE COUNTY



SEPTEMBER 18, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER - 550083

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Flood Boundary and Floodway Map Index
Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

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FLOOD INSURANCE STUDY

CITY OF MADISON,
DANE COUNTY,
WISCONSIN

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Madison, Dane County, Wisconsin, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound flood plain management. Minimum flood plain management requirements for participation in the National Flood Insurance Program are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The hydrologic and hydraulic analyses for Starkweather Creek, West Branch Starkweather Creek, East Branch Starkweather Creek, Portage Road Tributary, and Milwaukee Street Tributary were performed by Foth & Van Dyke of Madison, Inc. (the Study Contractor) for the Federal Emergency Management Agency (FEMA), under Contract No. EMW-83-C-1117.

The hydrologic and hydraulic analyses for Unnamed Tributary to Lake Waubesa, the Yahara River including Lake Mendota, Lake Monona, and Lake Waubesa, Nine Springs Creek, and Murphy Creek were performed by the U.S. Geological Survey (USGS), for FEMA under Inter-Agency Agreement No. IAA-H-9-77, Project Order No. 3. This study was completed in January 1985.

1.3 Coordination

Streams requiring detailed study were identified at a meeting attended by representatives of the Study Contractor, FEMA, Wisconsin Department of Natural Resources (WDNR), Dane County Regional Planning Commission, Dane County Public Works Department, the City of Madison Planning Department, and the City of Madison Engineering Division.

On October 23, 1985, the results of this Flood Insurance Study were reviewed and accepted at a final coordination meeting attended by representatives of the Study Contractor, FEMA, and the community.

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2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Madison, Dane County, Wisconsin. The area of study is shown on the Vicinity Map (Figure 1).

Flooding caused by overflow of the following streams was restudied in detail using updated hydrologic and hydraulic techniques:

a. Starkweather Creek, from the mouth to the confluence of West Branch Starkweather Creek;

b. West Branch Starkweather Creek, from the mouth to about 1.2 miles upstream of U.S. Highway 51;

c. East Branch Starkweather Creek, from the mouth to about 1,050 feet upstream of Lien Road;

d. Portage Road Tributary, from the mouth to just upstream of Hayes Road; and

e. Milwaukee Street Tributary, from the mouth to Milwaukee Street.

Flooding caused by overflow of the following streams was studied in detail in the Type 15 Flood Insurance Study for the City of Madison (Reference 1):

a. Unnamed Tributary to Lake Waubesa, from about 0.2 mile downstream of U.S. Highway 51 to about 0.6 mile upstream of Marsh Road;

b. Yahara River, including Lake Mendota, Lake Monona, and Lake Waubesa, throughout the river reaches and lakeshore areas, from about 0.8 mile downstream of the confluence of Nine Springs Creek to about 2.0 miles upstream of State Highway 113;

c. Nine Springs Creek, from the mouth to about 1,000 feet upstream of Syene Road; and

d. Murphy Creek, from the mouth to about 600 feet upstream of Haywood Drive.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards.

The areas studied were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through January 1990. The scope and methods of study were proposed to and agreed upon by FEMA and the City of Madison.

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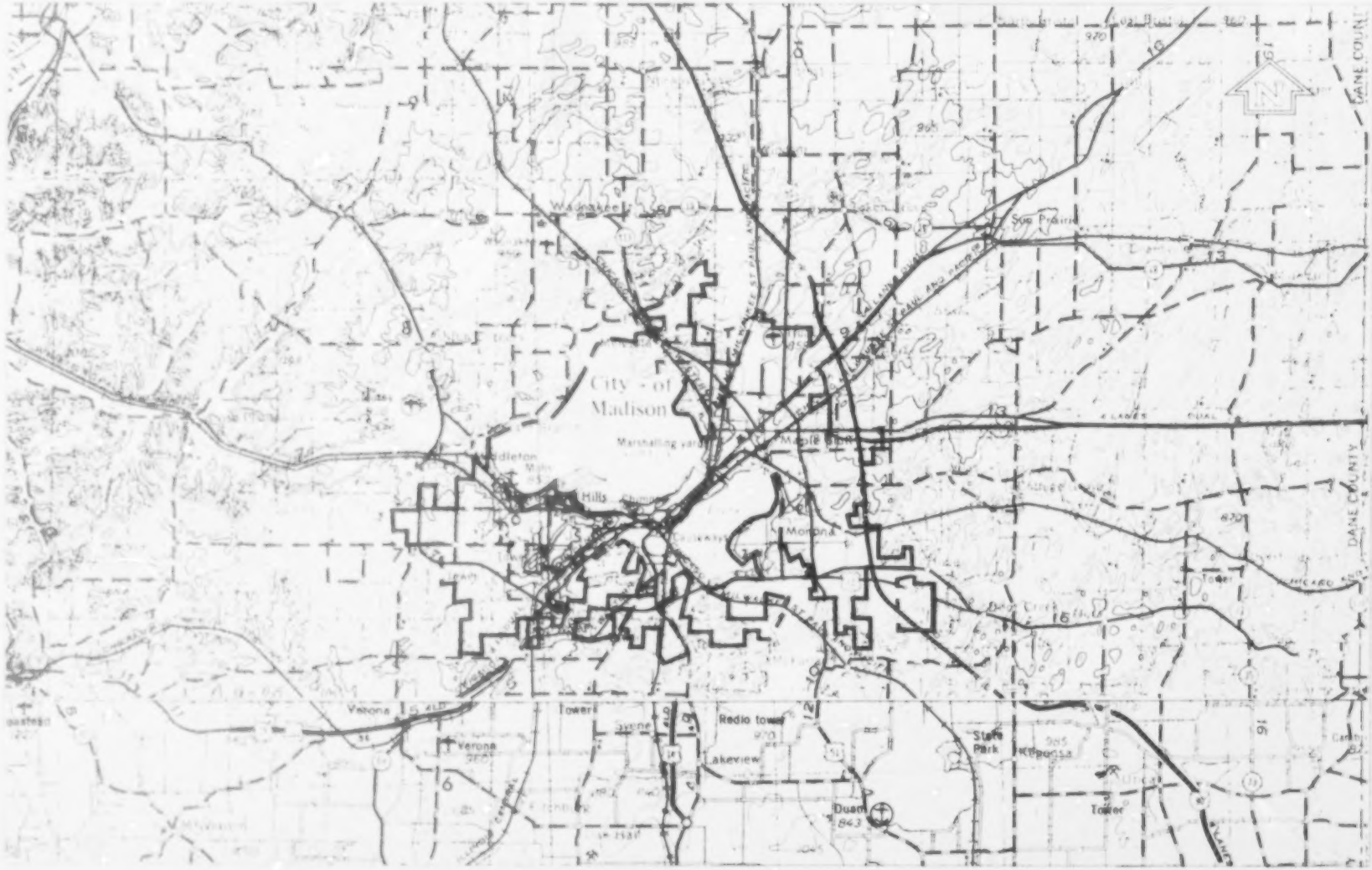

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

2.2 Community Description

The City of Madison is located in south-central Wisconsin in central Dane County. Madison is bounded by the City of Monona on the eastern side of Lake Monona, the Village of Maple Bluff on the northeastern side of Lake Mendota, and the Village of Shorewood Hills on the southwestern side of Lake Mendota. The Village of McFarland to the southeast, the City of Fitchburg to the south and the Village of Middleton to the west have common boundaries with Madison. The City of Milwaukee is about 80 miles east of Madison. In 1980, the population of Madison was reported to be 170,616 (Reference 2).

Climatic characteristics in Madison include summer temperatures that reach an average monthly high of 73 degrees Fahrenheit (F.) in July and an average monthly low of 62 degrees F. in September. The winter temperature averages a monthly high of 32 degrees F. in March and an average monthly low of 19 degrees F. in January. Annual precipitation is 30 inches (Reference 3).

Factors that affect flooding include soils, topography, geomorphology, land use, and vegetation. Soils in well-drained upland areas are mostly silt loams. Peat and muck soils occupy low-lying, poorly drained areas (Reference 4). Madison is located just northeast of the "Driftless Area" of southwestern Wisconsin. The glacially shaped topography of Madison and the surrounding area in central Dane County is irregular, ranging from flat and rolling to hummocky and hilly (Reference 5). The most prominent geomorphologic features were glacially formed. Among these are Lakes Mendota, Monona, Waubesa, Kegonsa, and Wingra, and moraines and drumlins. Glacial drift covers the entire area except for local areas of bedrock outcrop (Reference 4). The major land use in Madison is residential. The second greatest use is commercial. The University of Wisconsin occupies a large area along 2.0 miles of the south shore of Lake Mendota. Some land is used for agriculture in the outer fringe areas of the city. Most of the land surrounding Madison is cropland and pasture. Principal crops are corn and hay.

The Yahara River is the main drainage feature in the community. The Yahara River gradient is essentially flat where it flows through the lakes in Madison. Water-surface elevations are controlled mostly by dams at the outlets of Lakes Mendota and Waubesa. West Branch Starkweather Creek and East Branch Starkweather Creek drain a large part of northeastern Madison. An unnamed creek in southeastern Madison flows into the north end of Lake Waubesa. Underground storm sewers discharging into Lake Mendota and Lake Wingra provide local drainage for much of the western part of the city.

Patterns of development in Madison are varied. Residential and commercial development is interspersed throughout the city. New residential development is expanding most rapidly in the following areas of the city: west to the Gammon Road area; southwest to south of Raymond Road; east to north and south of Cottage Grove Road; and northeast to the Portage Road area. Commercial development density is greatest in the central part of the city between Lake Mendota and Lake Monona, along major thoroughfares, and at numerous shopping centers throughout the city. Development in the flood plain is also varied. From the mouth of

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Starkweather Creek and West Branch Starkweather Creek, development in the flood plain is mixed residential and commercial. Upstream of State Highway 30, flood plain use is primarily commercial, industrial, and unused open areas. The largest single feature is the Dane County Regional Airport. Near East Branch Starkweather Creek, use of flood plain is low density commercial and industrial. Around Unnamed Tributary to Lake Waubesa, the area is sparsely developed and contains scattered residential buildings and an industrial building. There is essentially no development in the Nine Springs Creek flood plain, which is mostly marshland, nor is there development in the Murphy Creek flood plain. Most low-lying areas along the Yahara River downstream of Lake Monona and areas along Lake Waubesa are undeveloped. Low-lying areas along Lakes Monona and Mendota and the Yahara River north of Lake Mendota are parkland or undeveloped.

2.3 Principal Flood Problems

Snowmelt is a factor considered in flooding, but its influence is incorporated into the technique used to determine stream flood discharges and in the lake gage records. Most significant in affecting flood magnitudes in Madison is a combination of snowmelt and rainfall runoff from frozen, impervious ground.

Dams at the outlets of Lake Mendota and Lake Waubesa increase upstream elevations on the Yahara River. Most Yahara River bridges have sufficient capacity to pass the 100-year flood with little backwater. Culverts on West Branch Starkweather Creek, particularly those at Fair Oaks Avenue, East Washington Avenue, and State Highway 30, cause considerable backwater. Heavy brush on the banks of Unnamed Tributary to Lake Waubesa decreases the channel capacity and causes backwater.

Flooding is not a serious problem in most of Madison. The most floodprone residential area is along West Branch Starkweather Creek south of Commercial Avenue. Large, mostly open areas in the vicinity of the Dane County Regional Airport are subject to flooding. Low-lying undeveloped areas in the northern part of the city along the Yahara River and southeastern part of the city along Lake Waubesa are subject to flooding.

Major flooding on West Branch Starkweather Creek at the downstream side of State Highway 51 occurred on April 1, 1959. The flood had a recurrence interval of 50 to 100 years and reached an elevation of 858.5 feet National Geodetic Vertical Datum of 1929 (NGVD). Major flooding on Lake Mendota with a recurrence interval greater than 100 years occurred on April 1, 1959, and reached an elevation of 852.01 feet NGVD. On July 28, 1929, a major flood with a 24-year recurrence interval occurred on Lake Monona. This flood reached an elevation level of 847.27 feet NGVD. Damage associated with the April 1959 flooding was confined mostly to areas along West Branch Starkweather Creek where basements were flooded in the North Marquette Street area (Reference 6). Large areas near and including most of the Dane County Regional Airport were also flooded (Reference 7).

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2.4 Flood Protection Measures

No significant flood protection structures exist on Madison streams. The primary function of the dams at the outlets of Lake Mendota and Lake Waubesa is to stabilize water-surface elevations in the lakes. The large storage capacities of the lakes dampen flood discharges on the Yahara River.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each riverine flooding source studied in detail affecting the community.

Peak discharges for Starkweather Creek, West Branch Starkweather Creek, East Branch Starkweather Creek, Portage Road Tributary, and Milwaukee Street Tributary were determined using the methodology outlined in the U.S. Soil Conservation Service (SCS) National Engineering Handbook (Reference 8). With this procedure, the time of concentration and the time of peak are computed for the basin and a unit hydrograph is developed. The expected 6-hour rainfall for the desired frequency event was obtained from Technical Paper No. 40 (Reference 9) and distributed into 30-minute amounts as described in the SCS criteria for design storms. A 6-hour duration was chosen due to the sub-basin sizes and to the SCS determination of being the "Effective Duration" for areas having an average annual precipitation of approximately 30 inches. Rainfall excess is computed from accumulated rainfall using an SCS runoff equation that equates runoff as a function of soil type, antecedent moisture condition, and land use. Using this precipitation data and the derived unit hydrograph, an outflow hydrograph is computed for the sub-basin.

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All storm-sewered areas were analyzed using the Illinois Urban Drainage Area Simulator (Reference 10). This computer model uses predicted rainfall and physical basin parameters to estimate runoff from both paved and grassed areas within a given watershed. To evaluate the storm sewer systems and their outflows, additional data such as diameter and slope for each of the storm sewer mains were required. The results of these sub-basin analyses were in the form of a time/discharge hydrograph that could be used as a time adjusted point inflow into the Starkweather Creek Stream System.

All other hydrologic analyses such as computing local runoff, channel routings, combination of hydrographs and storage area routings were completed using the U.S. Army Corps of Engineers (COE) computer program HEC-1 (Reference 11). This program uses the SCS technique, as previously described, for computing local runoff. It also uses the Kinematic Wave Distribution for channel routings and the modified PULS technique for storage area routings.

All models were verified using the historic rainfall event of July 1, 1978. According to the hourly rainfall gage found near the center of the Starkweather Creek watershed, 2.87 inches of precipitation fell in a 6-hour period. Simultaneously, discharges were being recorded by the U.S. Geological Survey (USGS) for an ongoing study completed by the Dane County Regional Planning Commission (Reference 12). The discharges and elevations computed by the various computer models were verified by the actual measured values for that storm.

The flood discharges for Unnamed Tributary to Lake Waubesa, with a predominantly rural basin, were determined by regional flood equations (Reference 13). Parameters in this analysis include drainage area, slope, lake and marsh area, and mean annual snow depth. The discharges were reviewed by the WDNR in a written communication in January 1978.

Peak discharges for the Yahara River and Nine Springs Creek were taken from the Flood Insurance Study for the Unincorporated Areas of Dane County (Reference 14).

A USGS lake-stage gaging station on Monona Bay at the western end of Lake Monona provided data from 1916 to 1977 for defining the stage-frequency relationship for Lake Monona and Lake Waubesa. A similar gage near the outlet of Lake Mendota provided data for the period from 1916 to 1977 for Lake Mendota. A statistical analysis of the observed annual peak stages using a log-Pearson Type III distribution provided estimates of the 10-, 50-, 100-, and 500-year peak elevations (Reference 15).

The hydrologic analysis for Murphy Creek was done in the following manner. A gaging station at the outlet of Lake Wingra, or upstream end of Murphy Creek, provided data from 1971 to 1977 for estimating the discharge-frequency relationship for Murphy Creek. A statistical analysis of the observed annual peak discharges using a log-Pearson Type III distribution provided estimates of the 10-, 50-, 100-, and 500-year peak discharges (Reference 15). The peak discharges are relatively small in relation to the hydraulic capacity of Murphy Creek. Consequently, peak flood elevations along Murphy Creek are caused by backwater from Lake Monona rather than drainage from Lake Wingra and adjacent land, so no profile is included in this report.

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Peak discharges for the 10-, 50-, 100-, and 500-year floods of each flooding source studied in detail in the community are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross-section data for Starkweather Creek, West Branch Starkweather Creek, East Branch Starkweather Creek, Portage Road Tributary, and Milwaukee Street Tributary were obtained by photogrammetric techniques and 2-foot contour maps generated as a result of this restudy (Reference 16).

Cross-section data for the remainder of the streams studied in detail were obtained from channel, bridge, and culvert geometry that was field surveyed by the USGS. Overbank cross-section data were scaled from 2-foot contour maps (Reference 17).

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the Flood Boundary and Floodway Map.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field inspection. Roughness values for the streams studied in detail are shown below.

	Manning's "n"	
Flooding Source	Channel	Overbank
Starkweather Creek and West Branch Starkweather Creek	0.04 - 0.05	0.06 - 0.07
East Branch Starkweather Creek	0.03 - 0.05	0.06 - 0.11
Portage Road Tributary	0.045	0.08
Milwaukee Street Tributary	0.035 - 0.045	0.08 - 0.12
Unnamed Tributary to Lake Waubesa	0.035 - 0.045	0.030 - 0.100
Yahara River	0.030 - 0.040	*
Nine Springs Creek	0.035 - 0.050	0.040 - 0.140

*there was no overbank flow for the Yahara River

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TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA SQ MILES	PEAK DISCHARGES (CFS) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
STARKWEATHER CREEK					
at mouth	22.6	710	1,020	1,370	1,850
at Chicago and North Western Railroad	20.7	620	870	1,020	1,300
WEST BRANCH STARKWEATHER CREEK					
at Fair Oaks Avenue	11.7	320	420	480	600
at East Washington Avenue	11.0	290	370	420	500
at Anderson Street	10.8	320	480	630	860
at Airport Service Road	9.6	450	600	700	900
at Darwin Road	8.2	230	260	270	300
at Hanson Road	1.0	110	210	270	450
EAST BRANCH STARKWEATHER CREEK					
at mouth	8.8	290	420	510	650
at Lien Road	6.3	80	280	340	480
PORTAGE ROAD TRIBUTARY					
at mouth	1.9	220	420	550	900
MILWAUKEE STREET TRIBUTARY					
at mouth	1.5	300	450	525	650

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TABLE 1 - SUMMARY OF DISCHARGES (Continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA SQ MILES	PEAK DISCHARGES (CFS) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
UNNAMED TRIBUTARY TO LAKE WAUBESA					
at downstream corporate limit	7.90	200	510	630	985
at upstream corporate limit	2.68	160	310	390	650
YAHARA RIVER					
at USGS gage at outlet of Lake Waubesa	327	620	790	860	1,030
NINE SPRINGS CREEK					
at Moorland Road	10.9	260	520	700	1,340
MURPHY CREEK					
at USGS gage at outlet of Lake Wingra	6.08	46	59	66	80

Starting water-surface elevations for Starkweather Creek and West Branch Starkweather Creek were obtained from the 10-year peak flood elevation from Lake Monona. The starting water-surface elevations for Milwaukee Street Tributary were obtained from the flood elevations at its confluence with East Branch Starkweather Creek. Starting water-surface elevations for East Branch Starkweather Creek and Portage Road Tributary were obtained from the flood elevations at their confluences with West Branch Starkweather Creek. The starting water-surface elevations for Unnamed Tributary to Lake Waubesa were obtained from the peak flood elevations from Lake Waubesa. Starting water-surface elevations for the Yahara River and Nine Springs Creek were obtained from the Dane County Flood Insurance Study (Reference 14). Starting water-surface elevations for Murphy Creek were obtained from an average of the water-surface elevations for Lake Monona.

Water-surface elevations for Starkweather Creek, West Branch Starkweather Creek, East Branch Starkweather Creek, Portage Road Tributary, Milwaukee Street Tributary, and Unnamed Tributary to Lake Waubesa were computed using the COE HEC-2 step-backwater computer program (Reference 18). Water-surface elevations for the Yahara River and Nine Springs Creek were taken from the Flood Insurance Study for the Unincorporated Areas of Dane County (Reference 14).

Flood elevations caused by flood discharges were determined for Murphy Creek. These elevations were lower than flood elevations for Lake Monona. Hence, peak flood elevations for Murphy Creek are the same as the elevations for Lake Monona and are caused by backwater from Lake Monona. A summary of elevations is shown in Table 2.

TABLE 2 - SUMMARY OF ELEVATIONS

LOCATION	ELEVATIONS (NGVD) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
LAKE WAUBESA	846.6	847.2	847.4	847.8
LAKE MONONA	846.9	847.5	847.7	848.2
LAKE MENDOTA	851.0	851.5	851.7	852.1

Stages for all necessary storage areas were derived using the modified PULS option of the COE program HEC 1 (Reference 11). The discharge rating curves were computed based on the hydraulic capacities of the downstream culverts near their outflows. Storage was estimated using the 2-foot contour maps generated for this study (Reference 17).

Flood profiles were drawn showing the computed water-surface elevations for floods of the selected recurrence intervals. In cases where the 50- and 100-year flood elevations are close together, due to limitations of the profile scale, only the 100-year profile has been drawn.

The hydraulic analyses for this study are based only on the effects of unobstructed flow. The flood elevations shown on the profiles are, thus, considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

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All elevations are referenced to the NGVD. Elevation reference marks used in this study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:4800 with a contour interval of 2 feet and at a scale of 1:1200 with a contour interval of 2 feet (References 16 and 17).

For the streams studied by approximate methods, only the 100-year flood plain boundary was delineated using the Type 15 Flood Insurance Study for the City of Madison (Reference 1).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map. In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces the flood-carrying capacity, increases the flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. However, the WDNR has established a policy that limits encroachment in the flood plain to 0.1 foot (Reference 19).

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The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed and are presented in Table 3, Floodway Data.

A floodway was not computed for Murphy Creek because the peak flood elevations are the result of backwater from Lake Monona rather than flow from the Murphy Creek drainage basin. With concurrence from FEMA, no floodway was computed for the Yahara River and Nine Springs Creek. Floodways for portions of East Branch Starkweather Creek, West Branch Starkweather Creek, and Milwaukee Street Tributary were not computed in storage areas where hydraulic analyses do not apply.

As shown on the Flood Boundary and Floodway Map, the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and the 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown. Portions of the floodway of East Branch Starkweather Creek and Portage Road Tributary lie outside the corporate limits.

The area between the floodway and the 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 0.1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

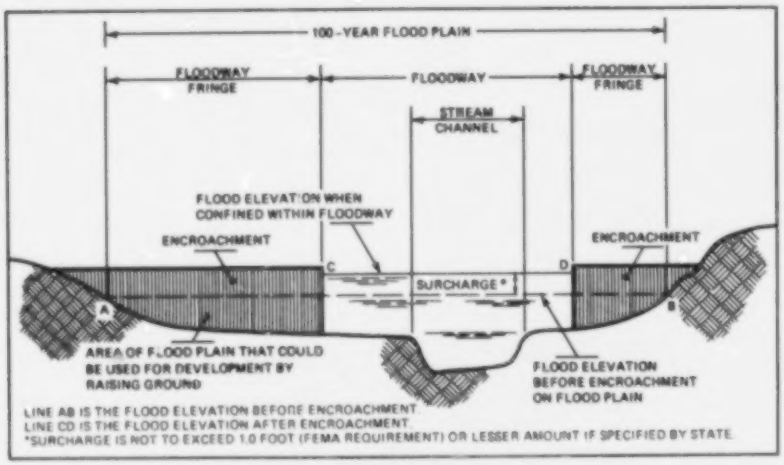
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE *
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FIGURE 2 - Floodway Schematic

The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE (FEET)
STARKWEATHER CREEK								
A	150	132	547	2.5	847.7	846.9[2]	846.9	0.0
B	432	44	261	5.2	847.7	847.1[2]	847.1	0.0
C	792	103	482	2.8	847.9	847.9	847.9	0.0
D	1391	104	420	2.4	848.1	848.1	848.1	0.0
E	1661	93	378	2.7	848.3	848.3	848.3	0.0
F	1891	76	431	2.4	848.5	848.5	848.5	0.0
G	2411	114	405	2.5	848.7	848.7	848.7	0.0
WEST BRANCH STARKWEATHER CREEK								
H	3061	174	475	1.0	848.9	848.9	848.9	0.0
I	3571	34	205	2.3	849.1	849.1	849.1	0.0
J	3761	43	186	2.6	849.2	849.2	849.2	0.0
K	4021	51	243	2.0	849.3	849.3	849.3	0.0
L	4585	52	214	2.2	849.7	849.7	849.7	0.0
M	4874	33	184	2.6	849.8	849.8	849.8	0.0
N	5249	123	237	2.0	850.2	850.2	850.2	0.0
O	5689	81	195	2.5	850.3	850.3	850.3	0.0
P	6079	218	454	1.1	850.7	850.7	850.7	0.0
Q	6408	88	182	2.6	850.9	850.9	850.9	0.0
R	6979	44	182	2.3	851.4	851.4	851.4	0.0
S	7214	113	251	1.7	851.5	851.5	851.5	0.0
T	7621	51	154	2.9	851.9	851.9	851.9	0.0
U	7996	209	492	0.9	851.9	851.9	851.9	0.0

[1]FEET ABOVE MOUTH
[2]ELEVATIONS WITHOUT CONSIDERING BACKWATER EFFECT FROM LAKE MONONA

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOODWAY DATA

STARKWEATHER CREEK—WEST BRANCH STARKWEATHER CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE (FEET)
WEST BRANCH STARKWEATHER CREEK								
V	13,050	71	324	1.9	852.5	852.5	852.5	0.0
W	13,655	249	417	1.5	852.8	852.8	852.8	0.0
X	14,125	81	306	2.1	853.2	853.2	853.2	0.0
Y	14,935	62	230	2.7	853.9	853.9	853.9	0.0
Z	15,265	59	249	2.5	854.4	854.4	854.4	0.0
AA	15,765	70	311	1.3	854.7	854.7	854.7	0.0
AB	16,565	52	226	1.2	855.0	855.0	855.0	0.0
AC	17,001	20	134	2.0	855.1	855.1	855.1	0.0
AD	17,771	55	208	1.3	855.4	855.4	855.4	0.0
AE	18,171	44	211	1.3	855.5	855.5	855.5	0.0
AF	18,878	67	293	0.9	855.6	855.6	855.6	0.0
AG	19,168	78	384	0.7	855.7	855.7	855.7	0.0
AH	22,850	49	220	1.0	855.7	855.7	855.7	0.0
AI	23,220	66	240	0.9	855.7	855.7	855.7	0.0
AJ	23,575	71	276	0.8	855.8	855.8	855.8	0.0
AK	24,050	35	181	1.2	855.8	855.8	855.8	0.0
AL	24,710	48	227	1.0	855.9	855.9	855.9	0.0
AM	25,235	48	157	1.4	856.0	856.0	856.0	0.0
AN	25,915	39	132	1.7	856.2	856.2	856.2	0.0
AO	26,615	33	139	1.6	856.4	856.4	856.4	0.0
AP	31,490	270[2]	371	2.6	858.4	858.4	858.4	0.0
AQ	31,910	640[2]	823	1.2	859.2	859.2	859.2	0.0
AR	33,320	890[2]	969	0.5	860.6	860.6	860.6	0.0
AS	33,965	1190[2]	1079	0.5	860.8	860.8	860.8	0.0

[1]FEET ABOVE MOUTH
[2]THIS WIDTH EXTENDS BEYOND CORPORATE LIMITS

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOODWAY DATA

WEST BRANCH STARKWEATHER CREEK

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE (FEET)
EAST BRANCH STARKWEATHER CREEK								
A	157	196	316	1.6	848.9	848.9	848.9	0.0
B	427	146	386	1.2	849.0	849.0	849.0	0.0
C	1027	27	146	3.3	849.1	849.1	849.1	0.0
D	7492	220	235	2.2	850.3	850.3	850.3	0.0
E	7967	245	524	1.0	851.1	851.1	851.1	0.0
F	8487	211	423	1.2	851.4	851.4	851.4	0.0
G	9019	35	206	2.1	851.8	851.8	851.8	0.0
H	9093	95	263	1.7	852.1	852.1	852.1	0.0
I	12,468	180	87	3.9	853.6	853.6	853.6	0.0
J	13,018	127	228	1.5	854.3	854.3	854.3	0.0

[1]FEET ABOVE MOUTH

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOODWAY DATA

EAST BRANCH STARKWEATHER CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE (FEET)
MILWAUKEE STREET TRIBUTARY								
A	860	194	653	0.8	850.4	850.4	850.4	0.0
B	1160	260	995	0.5	850.5	850.5	850.5	0.0
C	1680	260	992	0.5	850.5	850.5	850.5	0.0
D	2060	170	648	0.8	850.7	850.7	850.7	0.0
E	2550	92	277	2.0	851.0	851.0	851.0	0.0
F	3025	115	422	1.3	851.6	851.6	851.6	0.0
G	3440	28	87	6.3	852.8	852.8	852.8	0.0
H	3680	16	109	5.0	853.3	853.3	853.3	0.0
PORTAGE ROAD TRIBUTARY								
A	570	751	1645	0.3	860.0	860.0	860.0	0.0
B	1100	640	906	0.6	860.1	860.1	860.1	0.0
C	1770	330	723	0.7	860.3	860.3	860.3	0.0
D	2150	304	419	1.2	860.7	860.7	860.7	0.0
E	2590	250	259	1.9	861.7	861.7	861.7	0.0
F	3090	637	573	0.9	862.4	862.4	862.4	0.0
G	3710	568	518	1.0	863.1	863.1	863.1	0.0
H	4380	400	293	1.7	864.3	864.3	864.3	0.0
I	5645	131	307	1.3	878.8	878.8	878.8	0.0
J	5725	107	228	1.8	879.4	879.4	879.4	0.0
K	6845	44	98	4.1	889.0	889.0	889.0	0.0

[1]FEET ABOVE MOUTH

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOODWAY DATA

MILWAUKEE STREET TRIBUTARY—PORTAGE ROAD TRIBUTARY

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE (FEET)
UNNAMED TRIBUTARY TO LAKE WAUBESA								
A	0.06	82	200	3.17	850.0	850.0	850.0	0.0
B	0.10	99	240	2.67	850.4	850.4	850.4	0.0
C	0.14	142	210	2.98	850.9	850.9	850.9	0.0
D	0.15	80	250	2.56	851.2	851.2	851.2	0.0
E	0.16	80	270	2.30	851.3	851.3	851.3	0.0
F	0.20	69	280	2.28	852.0	852.0	852.0	0.0
G	0.22	200	780	0.81	852.4	852.4	852.4	0.0
H	0.31	122	340	1.85	852.6	852.6	852.6	0.0
I	0.33	140	210	3.06	852.6	852.6	852.6	0.0
J	0.35	38	160	4.03	852.9	852.9	852.9	0.0
K	0.43	270	470	1.35	853.6	853.6	853.6	0.0
L	0.50	270	160	1.32	853.8	853.8	853.8	0.0
M	0.61	36	180	3.91	854.2	854.2	854.2	0.0
N	0.70	41	180	3.46	855.0	855.0	855.0	0.0
O	0.79	86	230	2.58	855.8	855.8	855.8	0.0
P	0.96	39	180	3.26	856.6	856.6	856.6	0.0
Q	1.14	41	210	2.86	857.4	857.4	857.4	0.0
R	1.23	125	210	2.77	857.9	857.9	857.9	0.0
S	1.28	41	200	2.99	858.2	858.2	858.2	0.0
T	1.30	155	230	2.55	858.3	858.3	858.3	0.0
U	1.31	165	340	1.24	858.4	858.4	858.4	0.0
V	1.38	294	490	0.85	858.6	858.6	858.6	0.0
W	1.49	300	220	1.87	858.8	858.8	858.8	0.0
X	1.52	300	300	1.34	858.9	858.9	858.9	0.0
Y	1.67	242[2]	190	2.07	859.2	859.2	859.2	0.0
Z	1.85	31[2]	150	2.67	860.4	860.4	860.4	0.0

[1]MILES ABOVE CORPORATE LIMITS
[2]THIS WIDTH EXTENDS BEYOND CORPORATE LIMITS

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOODWAY DATA

UNNAMED TRIBUTARY TO LAKE WAUBESA

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Madison.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the weighted average difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the riverine flooding sources of the City of Madison are shown on the Flood Profiles and are summarized in Table 4, Flood Insurance Zone Data.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a riverine reach is the weighted average difference between the 10- and 100-year flood water-surface elevations rounded to the nearest 0.5 foot, multiplied by 10, and shown as a 3-digit code. For example, if the difference between elevations is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations are shown or FHFs determined.

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Zones A1 -- A4:	Special Flood Hazard Areas inundated by the 100-year flood, with base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- and 500-year floods by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and, areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding; not subdivided.

Flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are shown in Table 4, Flood Insurance Zone Data.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Madison is, for insurance purposes, the principal product of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines for riverine flooding sources show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the National Flood Insurance Program.

6.0 OTHER STUDIES

A Flood Insurance Study has been published for Dane County (Reference 14). Due to the updated hydraulic analysis used for West Branch Starkweather Creek, East Branch Starkweather Creek, and Portage Road Tributary in the City of Madison study, these two studies do not agree.

Flood Insurance Studies have been prepared for the City of Monona, the Village of McFarland, and the City of Middleton (References 20-22). The results of these studies agree with the City of Madison Flood Insurance Study.

A Flood Insurance Study is currently being prepared for the City of Fitchburg (Reference 23) and is in agreement with this Flood Insurance Study for the City of Madison.

Due to its more detailed analysis, this Flood Insurance Study supersedes the previously published Type 15 Flood Insurance Study for the City of Madison (Reference 1).

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
YAHARA RIVER							
REACH 1	0020	−0.8	−0.2	0.4	010	A2	VARIES—SEE MAP
REACH 2	0017,0020	−0.8	−0.2	0.4	010	A2	VARIES—SEE MAP
REACH 3	0015,0022	−1.8	−0.6	1.7	020	A4	VARIES—SEE MAP
NINE SPRINGS CREEK							
REACH 1	0010,0020	−1.5	−0.6	2.1	015	A3	VARIES—SEE MAP
STARKWEATHER CREEK							
REACH 1	0019	−1.5	−0.6	1.0	015	A3	VARIES—SEE MAP
WEST BRANCH STARKWEATHER CREEK							
REACH 1	0017,0019,0021, 0022,0023,0024	−1.1	−0.4	0.5	010	A2	VARIES—SEE MAP
EAST BRANCH STARKWEATHER CREEK							
REACH 1	0019,0023	−1.5	−0.6	0.8	015	A3	VARIES—SEE MAP

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOOD INSURANCE ZONE DATA

YAHARA RIVER—NINE SPRINGS CREEK—STARKWEATHER CREEK—WEST BRANCH STARKWEATHER CREEK—EAST BRANCH STARKWEATHER CREEK

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
MILWAUKEE STREET TRIBUTARY							
REACH 1	0019	−1.6	−0.7	0.9	015	A3	VARIES—SEE MAP
PORTAGE ROAD TRIBUTARY							
REACH 1	0023,0024	−0.9	−0.2	0.6	010	A2	VARIES—SEE MAP
UNNAMED TRIBUTARY TO LAKE WAUBESA							
REACH 1	0020,0030	−2.1	−0.6	1.6	020	A4	VARIES—SEE MAP
LAKE WAUBESA							
REACH 1	0020	−0.8	−0.2	0.4	010	A2	847
LAKE MENDOTA							
REACH 1	0005,0010,0015, 0017,0021	−0.7	−0.2	0.4	005	A1	852
LAKE MONONA							
REACH 1	0010,0017,0019, 0020	−0.8	−0.2	0.5	010	A2	848

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOOD INSURANCE ZONE DATA

MILWAUKEE STREET TRIBUTARY—PORTAGE ROAD TRIBUTARY—UNNAMED TRIBUTARY TO LAKE WAUBESA—LAKE WAUBESA—LAKE MENDOTA—LAKE MONONA

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, 300 South Wacker Drive, Chicago, Illinois 60606.

8.0 REFERENCES AND BIBLIOGRAPHY

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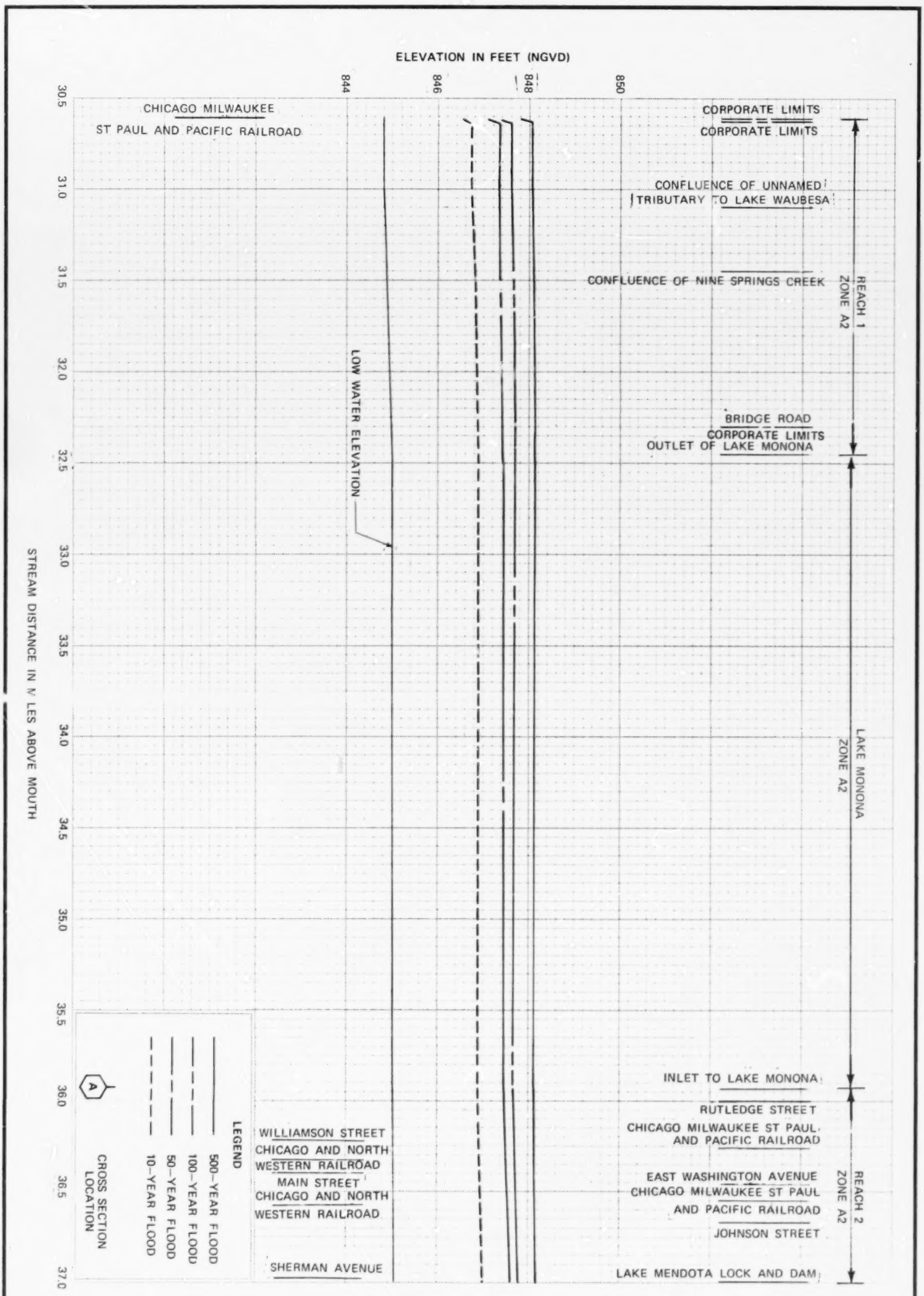

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI
(DANE CO.)

FLOOD PROFILES

YAHARA RIVER

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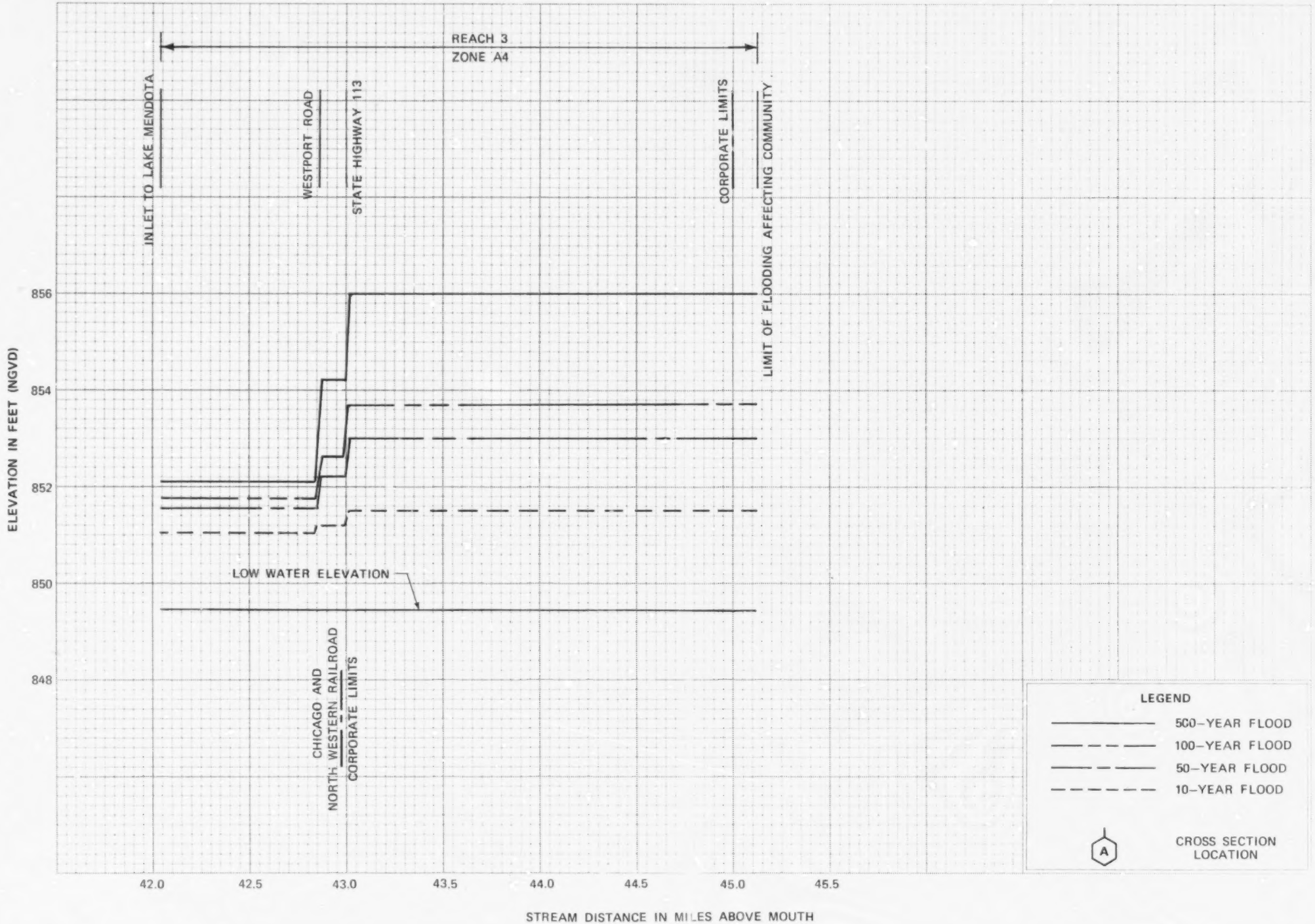

FLOOD PROFILES

YAHARA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI
(DANE CO.)

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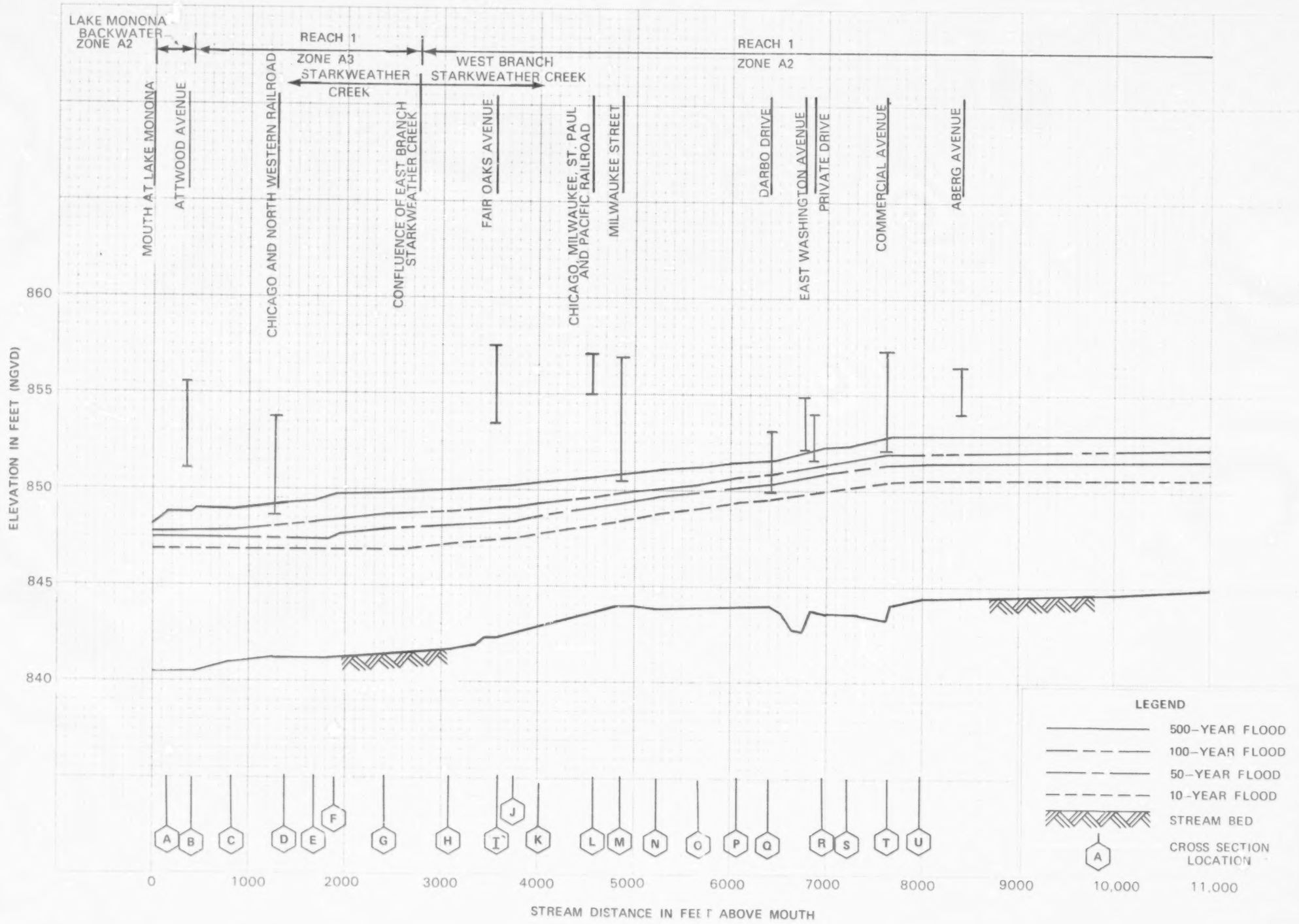

FLOOD PROFILES

STARKWEATHER CREEK—WEST BRANCH STARKWEATHER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI
(DANE CO.)

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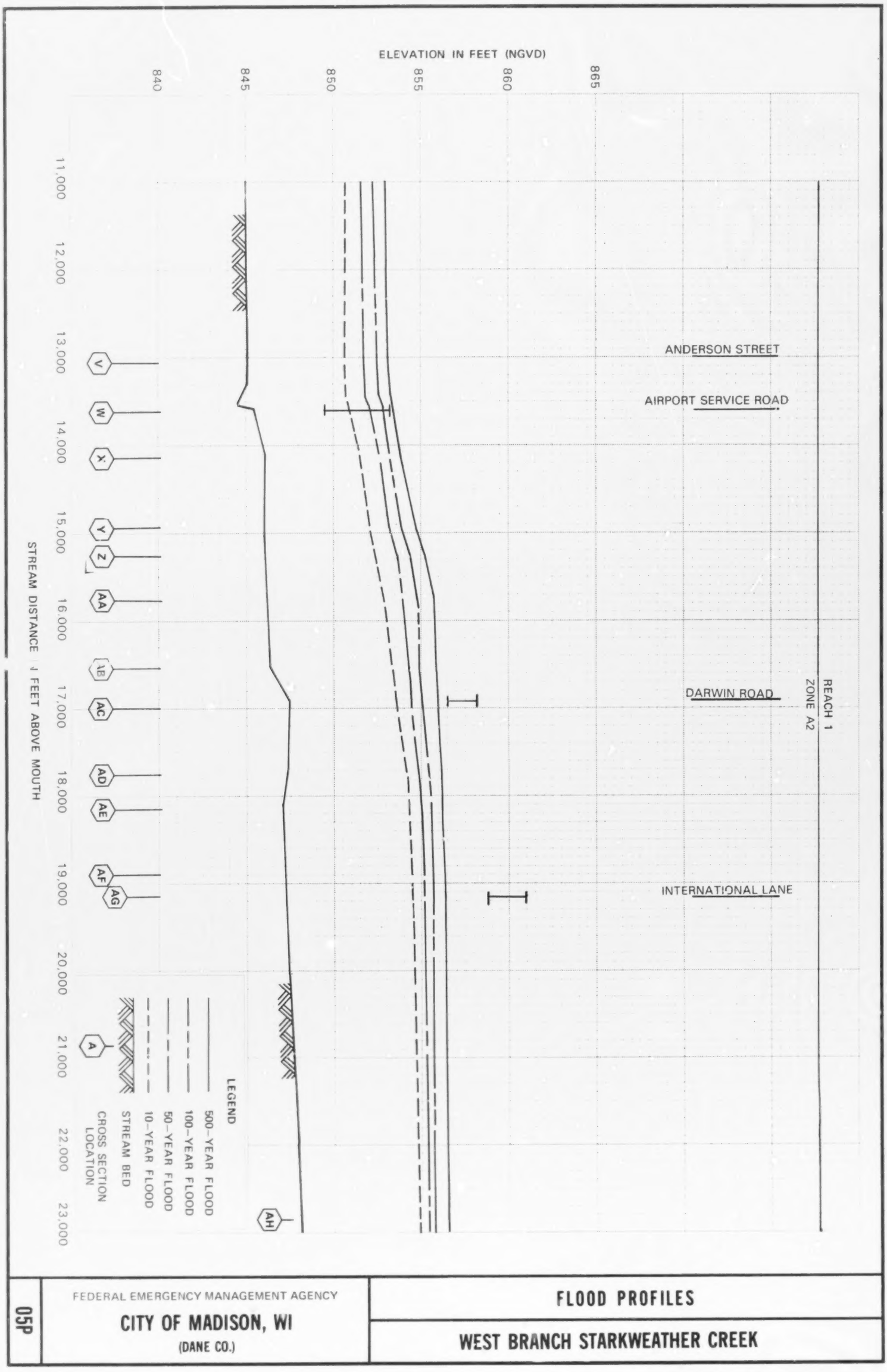

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

FLOOD PROFILES

WEST BRANCH STARKWEATHER CREEK

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FLOOD PROFILES

WEST BRANCH STARKWEATHER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

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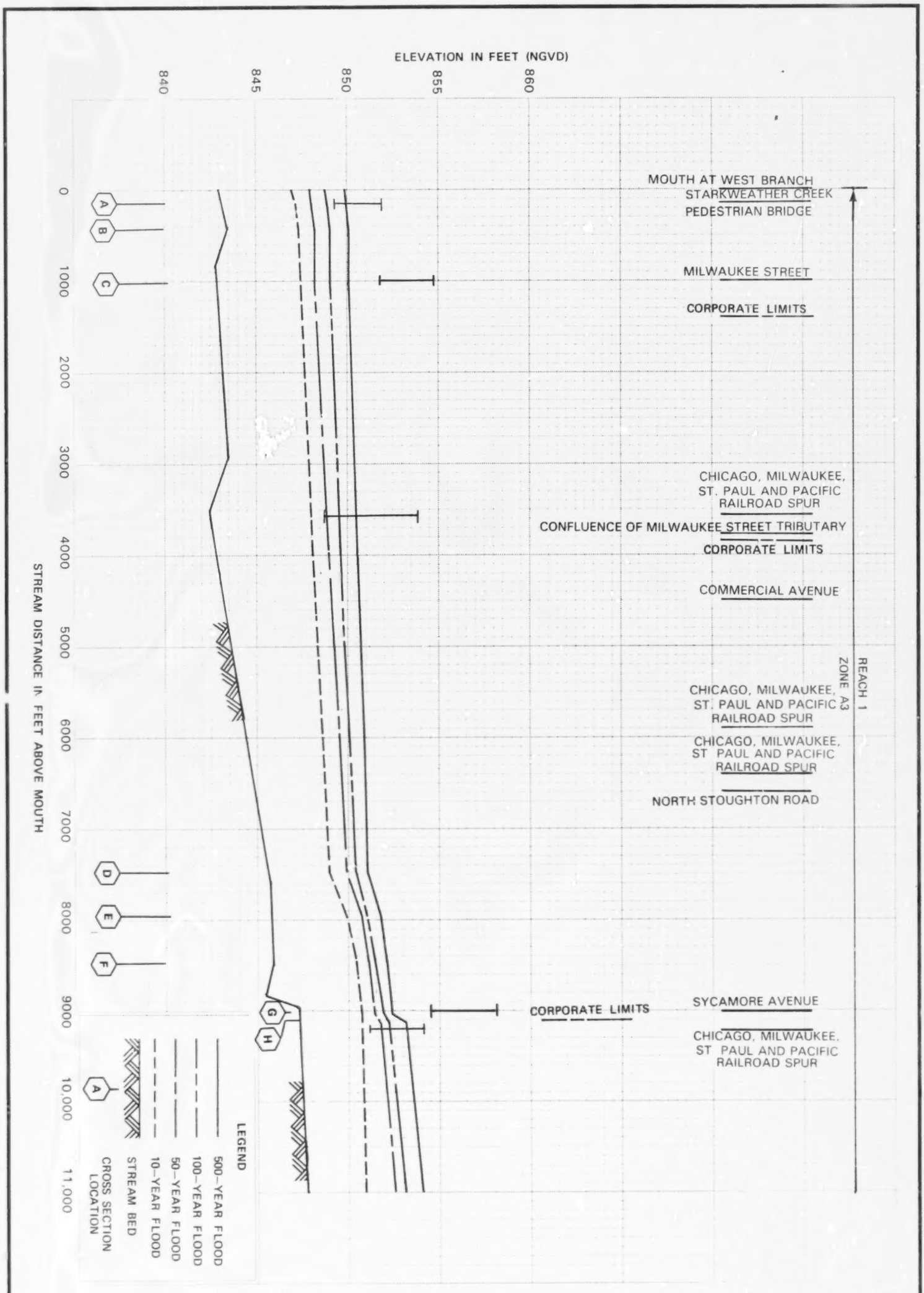

07P	FEDERAL EMERGENCY MANAGEMENT AGENCY CITY OF MADISON, WI (DANE CO.)	FLOOD PROFILES EAST BRANCH STARKWEATHER CREEK

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FLOOD PROFILES

EAST BRANCH STARKWEATHER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

08P

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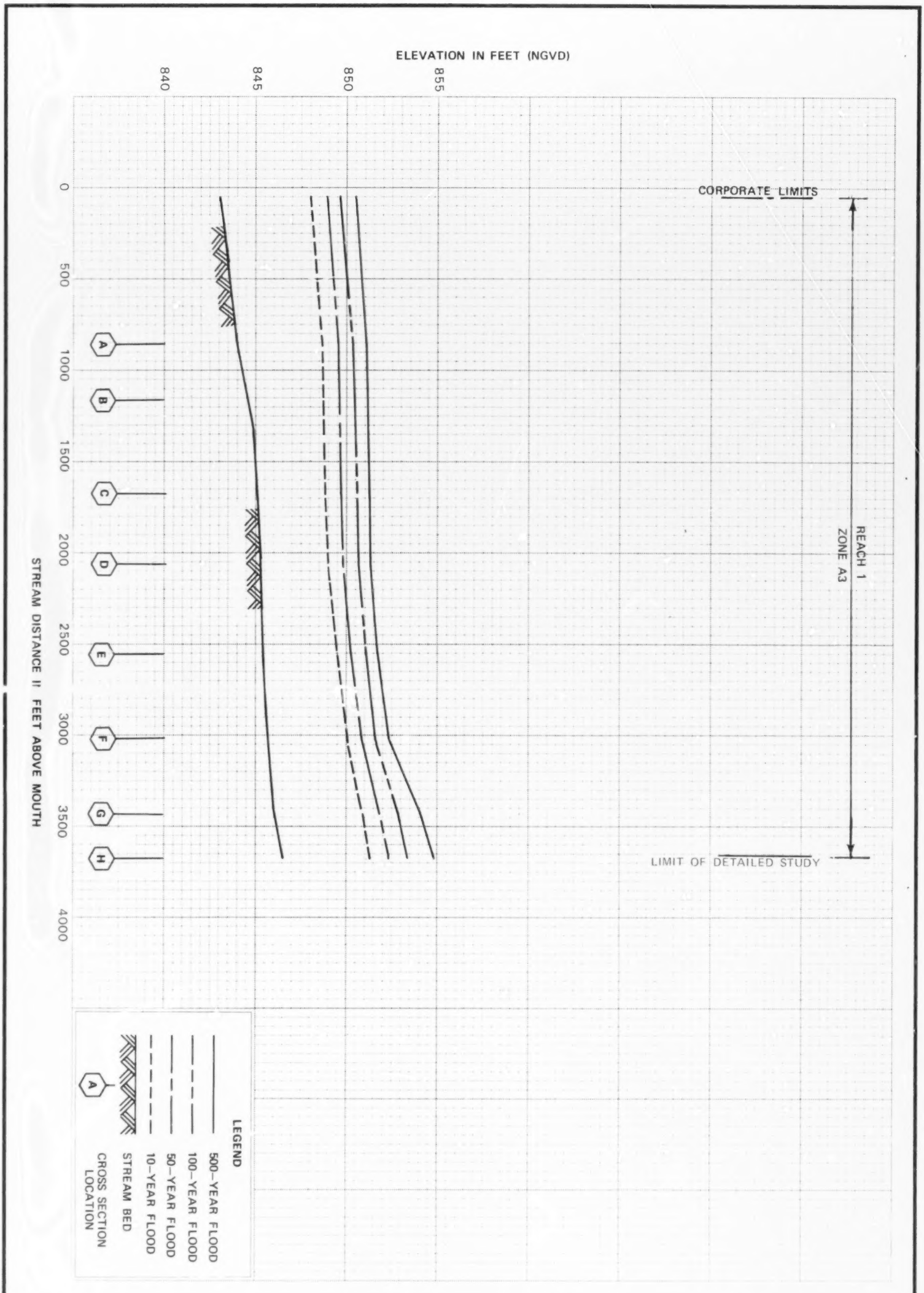

32

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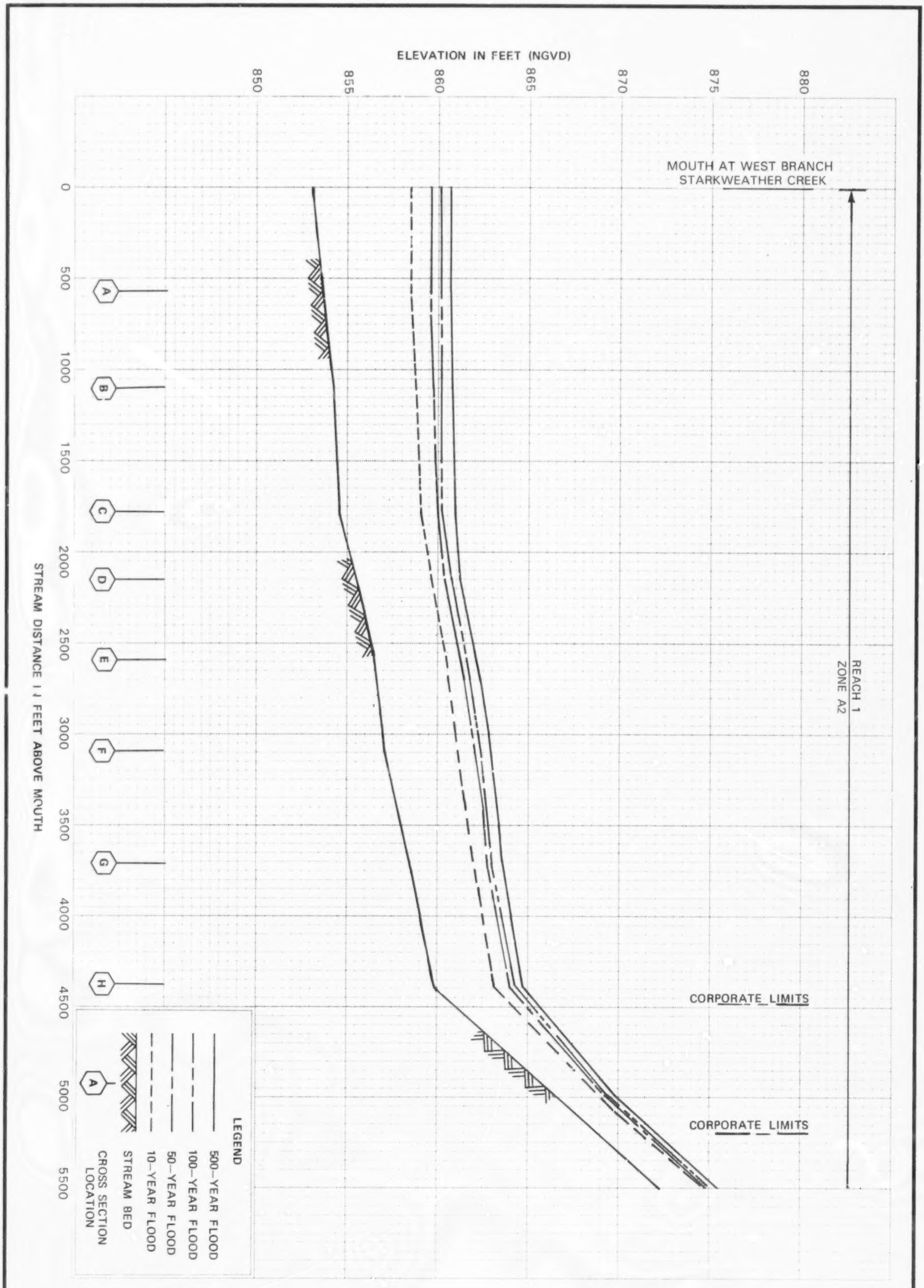
09P	FEDERAL EMERGENCY MANAGEMENT AGENCY CITY OF MADISON, WI (DANE CO.)	FLOOD PROFILES MILWAUKEE STREET TRIBUTARY



10P	FEDERAL EMERGENCY MANAGEMENT AGENCY CITY OF MADISON, WI (DANE CO.)	FLOOD PROFILES PORTAGE ROAD TRIBUTARY

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FLOOD PROFILES

PORTAGE ROAD TRIBUTARY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI

(DANE CO.)

11P

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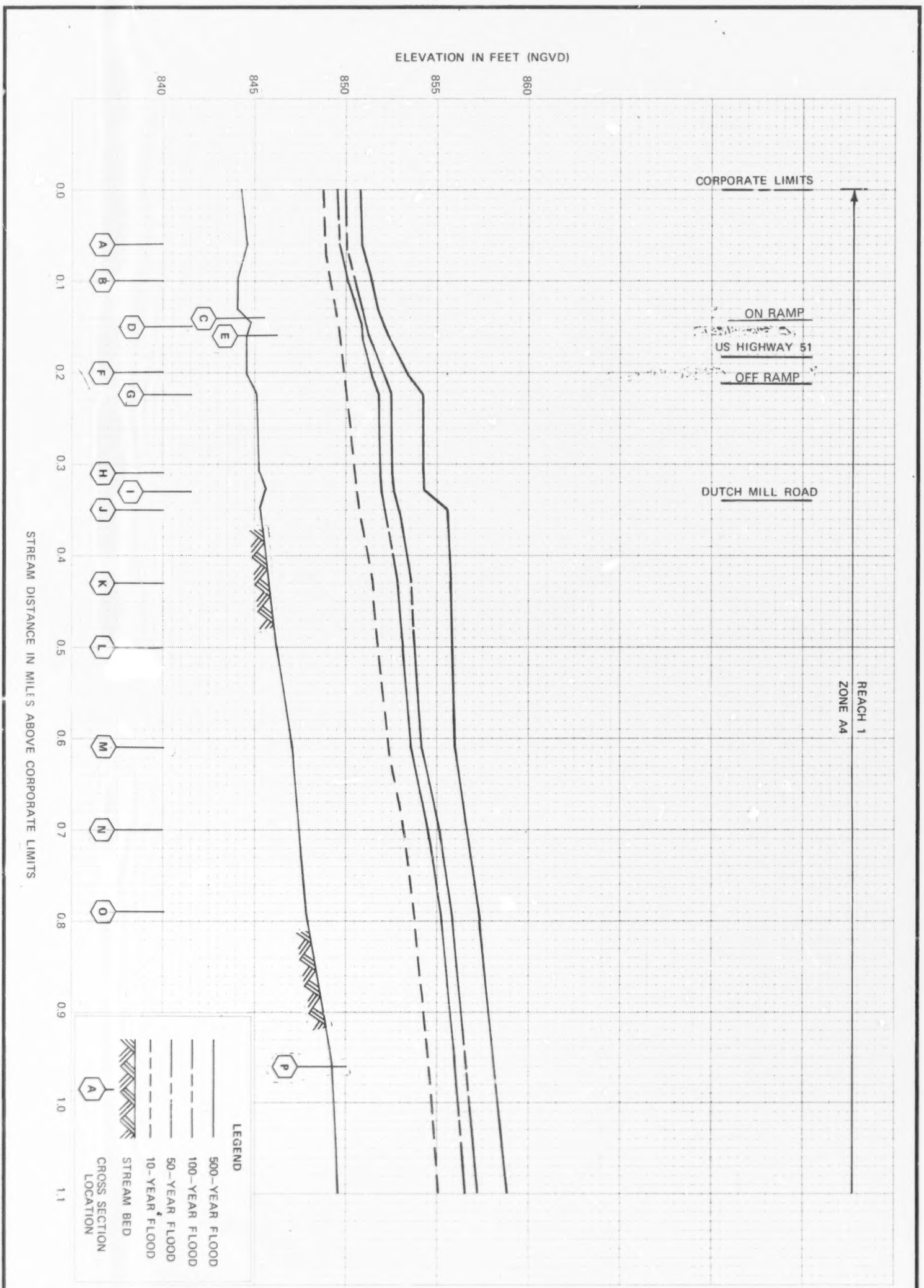

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MADISON, WI
(DANE CO.)

12P

FLOOD PROFILES

UNNAMED TRIBUTARY TO LAKE WAUBESA

35

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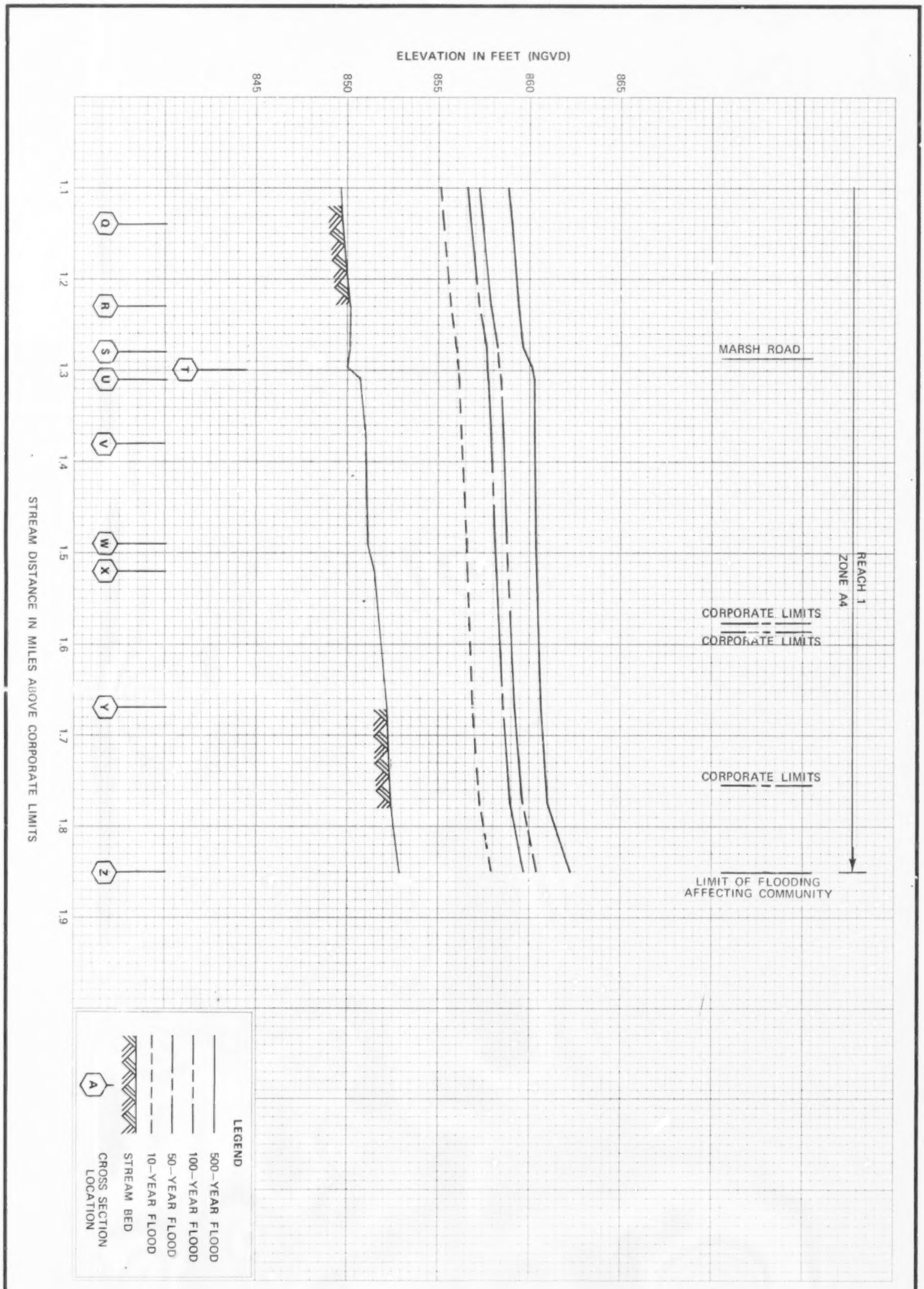

FEDERAL EMERGENCY MANAGEMENT AGENCY

13P

CITY OF MADISON, WI
(DANE CO.)

FLOOD PROFILES

UNNAMED TRIBUTARY TO LAKE WAUBESA

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